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VISUALIZATION OF BATTLESPACE ENERGY (VIBE)

Sterling Software, Inc.

Michael J. Seakan and Anthony H. Colby

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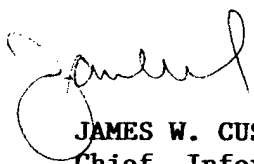ROME, NEW YORK**

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13. ABSTRACT *(Maximum 200 words)*

This report describes the Visualization of Battlespace Energy (VIBE) project developed by Sterling Software, Rome Department. VIBE was a research and development effort designed to demonstrate an innovative concept for calculating and graphically portraying the warfighting energy of military forces in the battlespace.

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SECTION 1 INTRODUCTION

This Final Technical Report (FTR) describes the Visualization of Battlespace Energy (ViBE) project developed by Sterling Software (U.S.), Inc. (Sterling Software), Rome Department. ViBE was a research and development effort designed to demonstrate an innovative concept for calculating and graphically portraying the warfighting energy level of military forces in the battlespace. This was a 24-month project sponsored by the Air Force Research Laboratory (AFRL) Information Directorate at Rome Research Site under contract F30602-99-C-0073. This FTR fulfills contract data item number A005.

1.1 Document Overview

This document provides background on the ViBE concept (Section 2), describes the ViBE software implementation and accomplishments (Section 3), and provides some conclusions and recommendations for follow-on exploration of the ViBE concept (Section 4).

1.2 Project Summary and Objectives

"The ultimate goal of C4 [command, control, communications, and computer] systems is to produce a picture of the battlespace that is accurate and meets the needs of warfighters. This goal is achieved by ... reducing information to the minimum essentials and putting it in a form that people can act on." (Joint Pub 6-0)

There were two major objectives for the ViBE project:

1. To process all-source intelligence data, consolidate it geospatially as energy that corresponds to the potential combat power of a military force, and display that energy on a map using an innovative visualization technique.

2. To integrate this visualization capability into the DataWall environment at the AFRL Information Directorate.

We achieved both objectives culminating in the final demonstration of ViBE on the AFRL Interactive DataWall on 27 April 2001.

VIBE accepts all-source intelligence data, creates data objects, applies user-specified weighting schemes, aggregates weighted objects in geo-grids of a size specified by the user, determines the summed grid weight, applies a user-specified color scheme, and displays those as a map overlay. The application includes many features to allow the user to select parameters that affect the performance the calculation of grid weights and display options, all through the use of the DataWall compatible mobile mouse-pointer. Section 3 describes in more detail the final software architecture and capabilities.

ViBE is an application that provides broad area visualization of battlespace activity in quantitative rather than qualitative terms. It offers the potential to provide an efficient front-end to support a host of artificial intelligence based campaign assessment and strategy development tools currently planned or already under development.

1.3 Reference Documents

1. *Software Design Document, Visualization of Battlespace Energy (ViBE)*, Sterling Software, Unclassified, December 1999.

2. *Software User's Manual, Visualization of Battlespace Energy (ViBE)*, Sterling Software, Unclassified, April 2001.

SECTION 2   BACKGROUND

The energy level of a military force has been a valuable metaphor used to describe the conduct of war and execution of military strategy. Energy directly relates to the enemy's combat potential – their ability to conduct war. It is also useful in identifying the physical center of gravity (COG) of an enemy force.

The goal of this effort was to translate the metaphor into a quantifiable parametric of combat potential. Given the assumption that the energy level of a military force can be sensed, calculated, and portrayed geospatially in various categories corresponding to air operations, ground operations, and electronic operations (radar and communications), various attributes of the combat potential of a military force can emerge. Specifically,

- Changes in the energy level over time provide a tangible measure of the relative success or failure of an ongoing military campaign.
- Geographic shifts in the energy pattern over time show general trends and movement of a military force, factors that are essential to strategy development.
- Relationships between energy levels across different categories (i.e., air, ground, and electronic) provide important insight into the enemy's mechanisms of war, mechanisms that are essential to targeting and center of gravity analysis.

The quantitative view of the battlespace is not a new concept. In the late 1980s, experiments performed under Rome Air Development Center's sponsored Advanced Sensor Exploitation (ASE) and Target Recognition for Electronic Combat (TREC) efforts, provided simulations that demonstrated the utility of geographically gridded quantitative analysis of sensor data to support Wide Area Surveillance. Unfortunately, because of inadequacies of real world sensor systems, computer processing, and display technologies of the late 1980s, an operational demonstration of the capability was never pursued.

Given the desire for new and innovative tools to support theater-level campaign planning, we needed to give this technology area a second look. Significant improvements in sensor systems, computer systems, and display technologies during the 1990s make this a technology area that is now both technically and operationally feasible.

2.1   AFRL DataWall

The ViBE software design and development focused on integration with the AFRL Information Directorate's Interactive DataWall. AFRL considers this capability to have significant potential for solving the information management challenges facing the next generation of military commanders. The DataWall combines commercial-off-the-shelf (COTS) technology with directorate-developed specialized hardware and software to provide a state-of-the-art multimedia data display and control capability. It features speaker-independent voice activation and a wireless pointing device using a camera-tracked laser pen. Three horizontally tiled liquid crystal display (LCD) projectors each display 1280 x 1024 pixels for a combined resolution of 3840 x

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1024 pixels across a 12 ft x 3 ft screen area, appropriate for use in larger command and control centers. Figure 2-1 illustrates this capability.
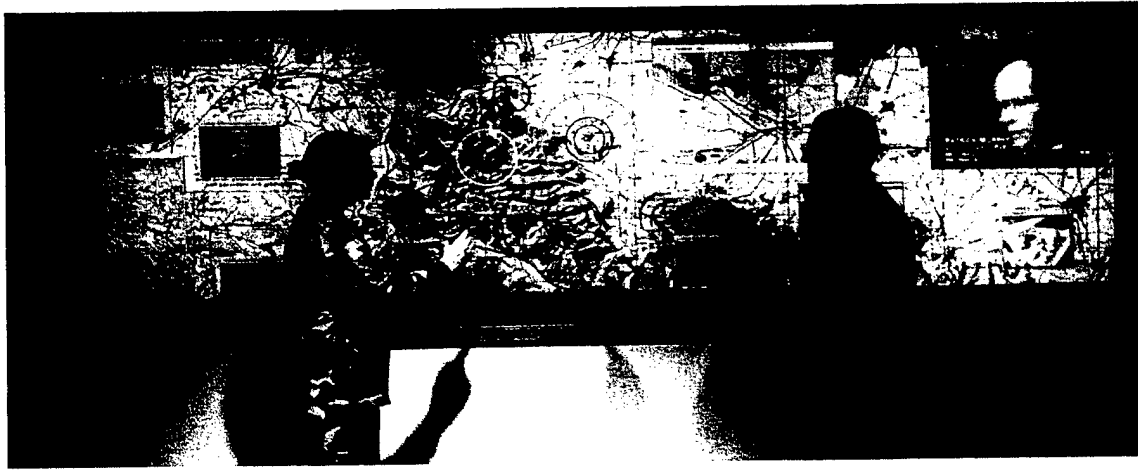
Figure 2-1: AFRL Interactive DataWall

2.2 Military Map Symbology

Military map displays normally include overlays with friendly (blue) and enemy (red) force unit dispositions represented by standard symbology. Each symbol indicates the size and type of unit. It is normally placed on the map at a location that represents the center of mass of the forces assigned to that unit. This can distort the true disposition of forces. For example, the battalions and companies organic to a brigade size force could be dispersed over a relatively large geographic area. It is difficult to discern the dispersion of those units from a single symbol. To account for that, battle staffs will seek a greater display resolution by de-aggregating the symbology and placing a symbol for each of the brigade's subordinate units at its respective geographic center of mass. This provides more information about the relative dispersion of units. However, it also creates an order of magnitude increase in the clutter on the map, making it much more difficult to identify a specific symbol.

The display shown in Figure 2-2 uses these types of military symbols. Most of the units displayed are brigade size units. Refining this to display battalion size units would triple the number of symbols.

As the number of symbols on the display increases, there could be a change in the value of the information. In areas where there are larger concentrations of enemy units, it will be useless to try to identify a particular symbol. However, one could use the intensity of red symbology to gain a feel for the relative density of enemy activity. That type of product offers potential for providing meaningful information about the enemy.

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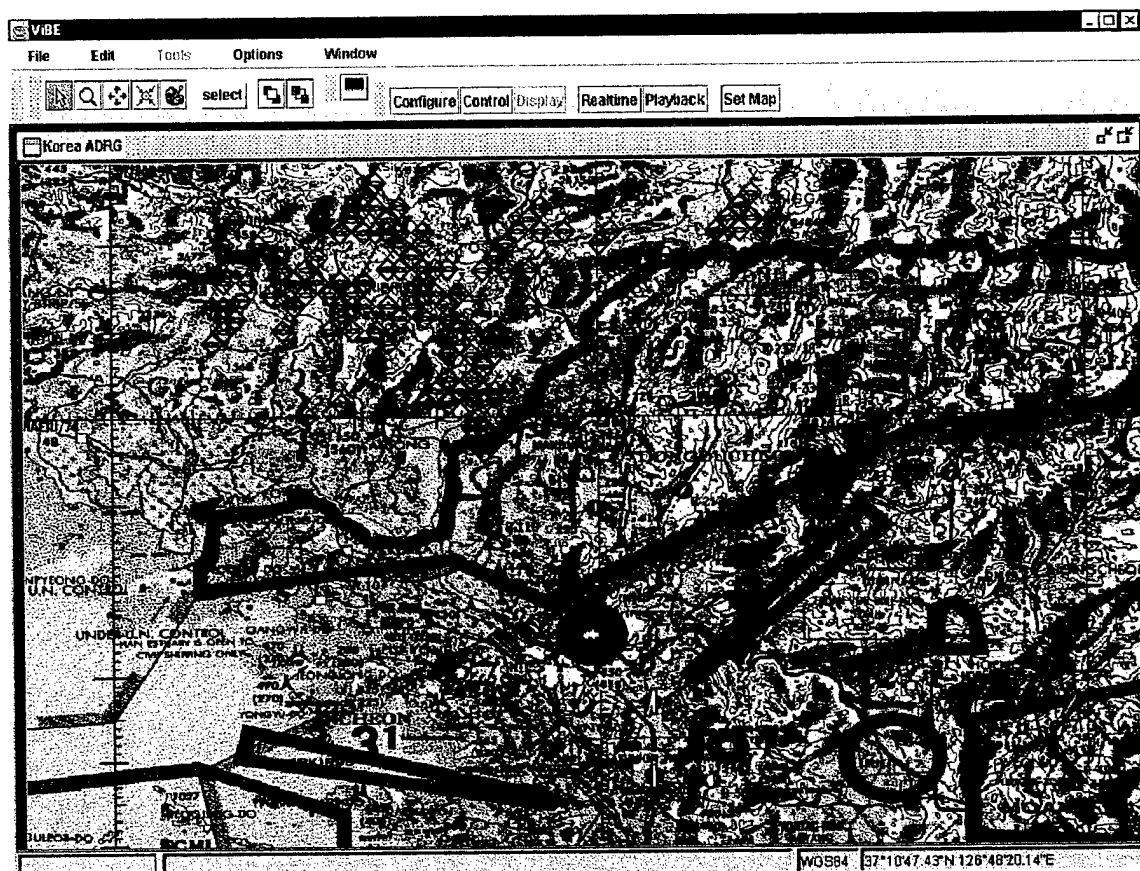
Figure 2-2: Map Display with Military Unit Symbology

2.3 Weather Radar Displays

The idea for the ViBE originated from the methodology used by meteorologists to display storm radar data. If there were a way to capture information about the density of enemy activity by geolocation and display that using the same visualization techniques used by weather radar models, we could provide a potentially more meaningful picture for use by military practitioners – or at least an innovative alternative.

Figure 2-3 shows a typical weather radar display. Many of us view something similar to this every day on television or through a web site. For comparison, we have superimposed the same blue force symbology and graphics as we used in the previous figure. Think of the colored storm radar images in the western area of the map as representing the actual disposition of the enemy forces derived from all-source intelligence data for enemy vehicles and emitters. Further, imagine capturing that data in the dimension of time and dynamically portraying it on the map in the same way that weather channels cycle through several hours of storm activity.

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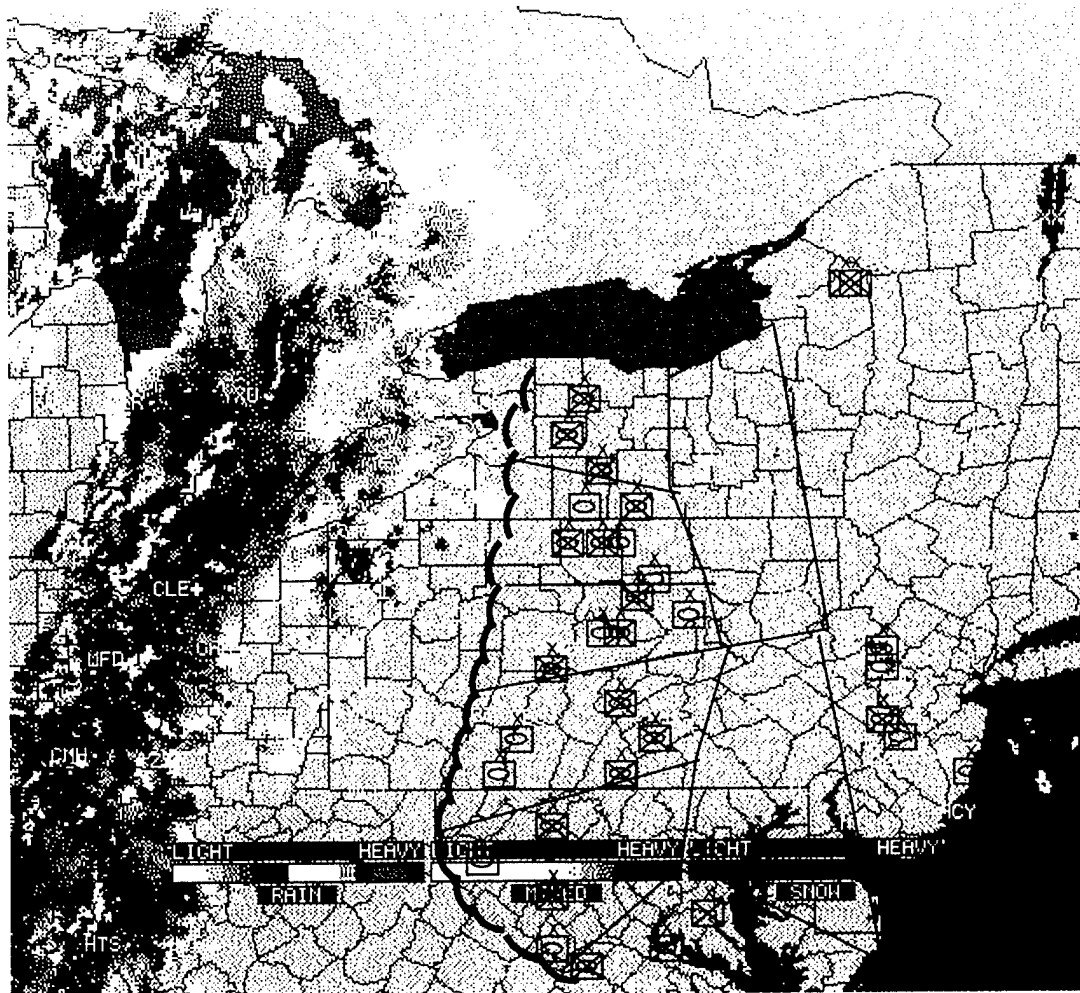
Figure 2-3: Weather Radar

2.4 ViBE Concepts

The ViBE system calculates and portrays the battlespace energy of a military force based on parsed United States Message Text Format (USMTF) messages. This offers a unique visualization option for situation displays of enemy activity. It emulates the display methods used for weather radar described in the previous section. We feel it is an especially valuable tool for commanders and battle staffs at the operational level. ViBE provides an easy-to-understand situational awareness capability. Its dynamic display capability also offers the insights into patterns of activity. In contrast to traditional military map-based situation displays, ViBE capitalizes on the human brain's capability to quickly process and assess visual images. With the cycling of weather radar images, the average person is able to quickly gain an understanding of approaching storm activity – how intense it is and roughly where it is headed. ViBE provides a similar image for enemy activity.

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2.4.1 Battlespace Energy

The military commander who can "see" where the enemy is, in what strength, and where the enemy is moving has a significant advantage. There are many ways to display the strength and location of enemy forces. However, most require study and analysis to acquire an understanding of the enemy's disposition of forces and capabilities. ViBE provides a "big picture" understanding of this.

Battlefield energy, in the context of ViBE, approximates the combat power of the enemy. It is derived from the same intelligence collectors that feed existing visualization capabilities. This includes using basic imagery and signals intelligence to produce objects that represent contact reports on vehicles, radars, or radios. The operator can assign a relative weight to each entity that represents its battlespace energy. For example, if a T-54 tank has a weight of 6.0, a T-80 tank would have a higher weight of say 9.0. This would represent the relatively greater combat power of a T-80 over a T-54. This weighting can be subjective and situation dependent. Therefore, in addition to providing a set of default weightings at system startup, ViBE provides the user with the capability to adjust these weights. ViBE groups these entities, according to options selected by the user, in geographical grids, and sums the weights to establish a grid energy level. The summed weight then represents the collective combat power present in that grid. ViBE translates that summed energy to a color for display purposes, providing the viewer with a colored map overlay depicting the battlespace energy.

2.4.2 Energy Display

"Warfighters understand things best in terms of ideas or images…" (From Joint Pub 6-0)

The ViBE user interface focuses on simplicity. It is a single window with interchangeable panes depending on selections made by the operator. When in display mode, there is a map background overlaid by grid cells with sensed and summed energy as described in the previous section.

ViBE has capabilities for the operator to easily adjust display parameters such as Grid Cell Size and filtering of entity groups (combat vehicle, target acquisition radar, VHF radios, etc.). A unique feature of ViBE is the capability to display sequential frames in order to "animate" the battlespace energy over time. The operator can select the number of frames, the time interval between frame updates (normally in minutes or hours), and the time interval between the display of these frames (in seconds). This provides a display of the battlespace energy that looks similar to the weather radar images discussed earlier. ViBE also offers a Playback mode for reviewing "older" energy pictures.

2.4.3 ViBE Architecture

ViBE can be thought of as a set of processes that correlate with its architectural components. Figure 2-4 provides a conceptual view of these processes and components.

The graphical user interface (GUI) offers two categories of visual display and two modes for set up and control of the display. As mentioned above, the operator has the option to display energy in realtime or in playback. The same underlying processes support both options. However, in the playback display option, the user selects the starting time, whereas in the realtime display option,

the combination of user-selected update interval and number of display frames (also user-selected) determines the starting time. The GUI provides the operator with the capability to easily reconfigure the display and reset display options.
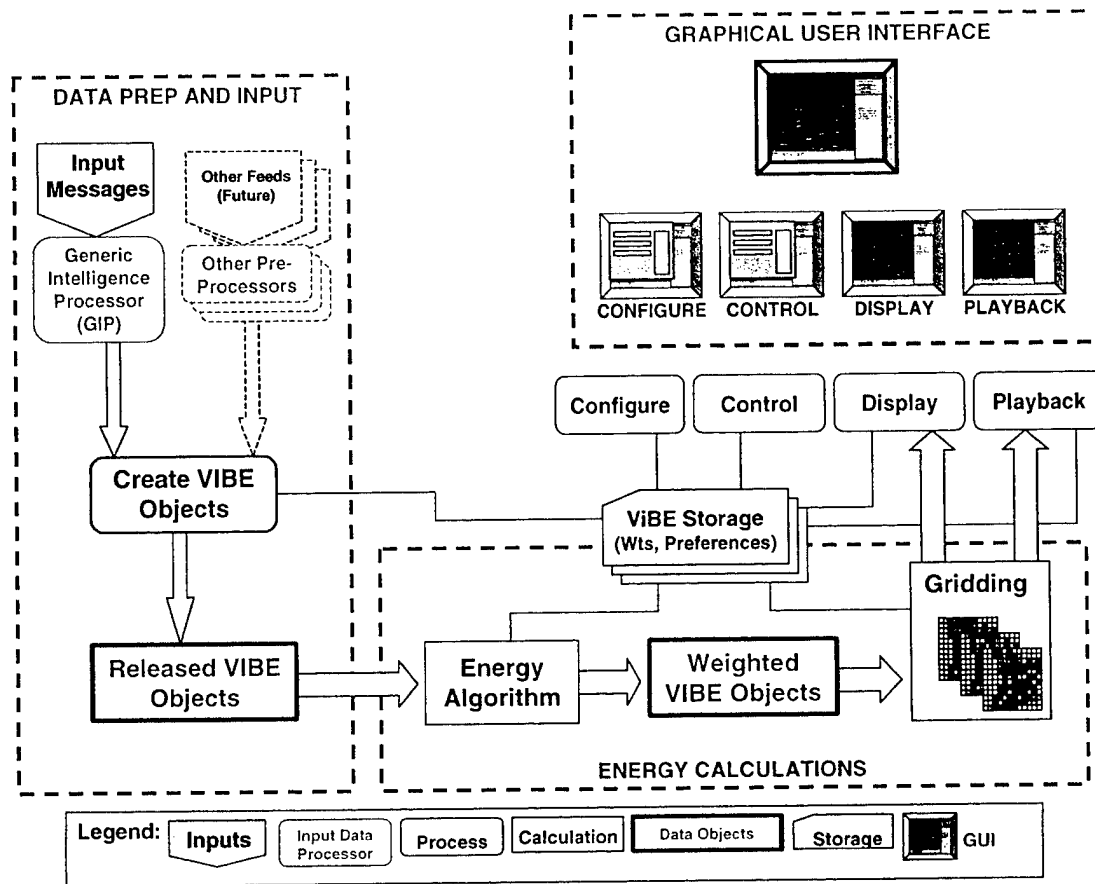
Figure 2-4: ViBE Architecture

The inputs into the ViBE architecture include various categories of all-source intelligence data. For this effort, input data was primarily derived from Signal Intelligence (SIGINT) and Imagery Intelligence (IMINT) contact reports. For later operational versions of the ViBE capability, many other forms of input can be integrated, such as Moving Target Indicator (MTI) data and Airborne Warning and Control System (AWACS) feeds. ViBE maps this intelligence data into ViBE Data Objects according to groupings of common type entities.

The energy calculation process attaches a weighted energy value to the ViBE object and assigns the weighted object to a grid cell. ViBE sums the weights of all objects in a cell, assigns a color to the cell based on that value, and builds the energy grid overlay for the GUI display.

Supporting each process are data files for accessing current weighting assignments and user preferences, such as Grid Cell Size, Frame Interval, Color Scheme, etc.

Section 3, Software Description and Capabilities, explains each of these processes in greater detail.

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SECTION 3 SOFTWARE DESCRIPTION AND CAPABILITIES

This section discusses the software as implemented and its capabilities.

3.1 Data Preparation and Input

3.1.1 Message Parsing

The primary inputs to ViBE include various categories of sensor data provided by different operational sensor systems in USMTF. These messages are first phase exploitation reports produced by sensor-preprocessors (e.g., TACREP, TACELINT, IIR, IPIR, REXREP and JSTARS MTI video).

The input to ViBE is currently passed from the source sensor systems through the Generic Intelligence Processor (GIP), which provides a message parsing capability that can be easily reconfigured and adapted to solve a specific problem. GIP's processing stream mode of operation supports processing and information extraction from formatted text messages. GIP parses each contact message reported by a sensor and formats it into a ViBE Input Object. The ViBE Input Object containing the following information: Message Time, Object Designation, Object Function Code, and Location. Each ViBE Input Object is then passed to the Object Interface.

3.1.2 Object Interface Module

The Object Interface Module performs the mapping of parsed sensor data entities to ViBE object groups and ViBE energy categories. In order to filter specific types of energy, ViBE breaks down the battlespace energy into categories. Each category of energy has associated with it numerous object types. For instance, the Combat Vehicles category may have associated with it object types tank1, tank2, tank3, IFV1 (Infantry Fighting Vehicle), IFV2, and so on.

The Object Interface Module reads a data file containing the associations, and builds an Entity Mapping hashtable. There is a many-to-one mapping of parsed data entities to ViBE object groups. (See Figure 3-1) The Object Interface Module retrieves the entity designation from the type associated with the reported contact and does a lookup in the Entity Mapping hashtable to determine which object group the entity maps to. The Object Interface then creates a ViBE Data Object containing: Object Group, Message Time, and Location. The ViBE Data Object is then sent to the Time Slice Directory to await processing by the Data Input Processor (See Section 3.1.3).

3.1.3 Data Input Process

The ViBE Data Input Process, illustrated in Figure 3-2, is used to retrieve ViBE Input Objects from the Time Slice Directory and parse the pertinent data from those ViBE Input Objects, creating ViBE Data Objects. The ViBE Data Input Process then populates a linked list containing all of the ViBE Data Objects for that time slice. The linked list containing the ViBE Data Objects is then passed to the Gridding Function to prepare them for display.
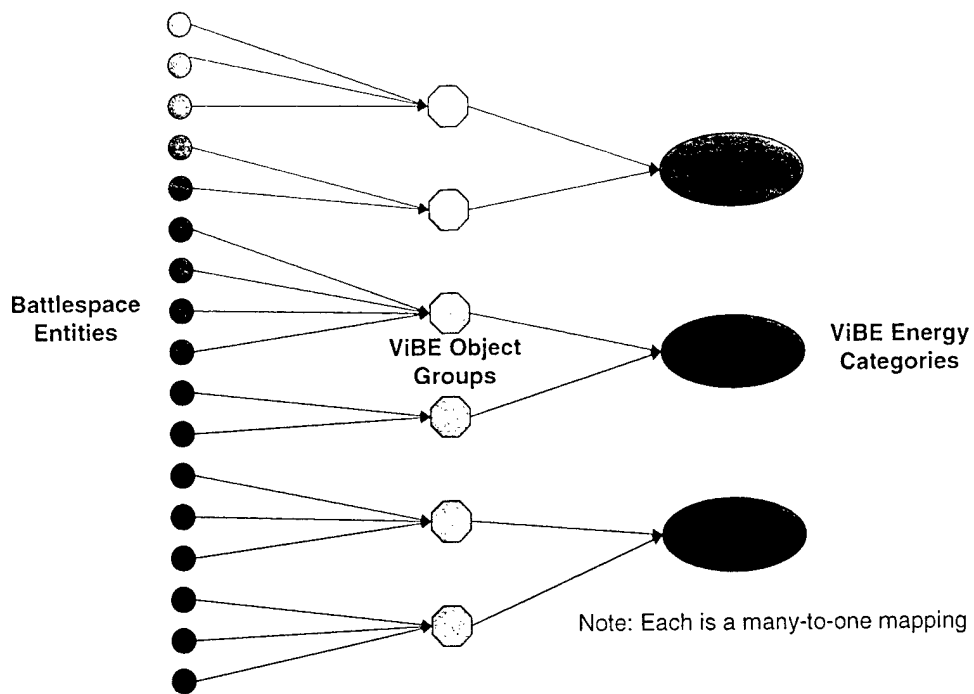
9
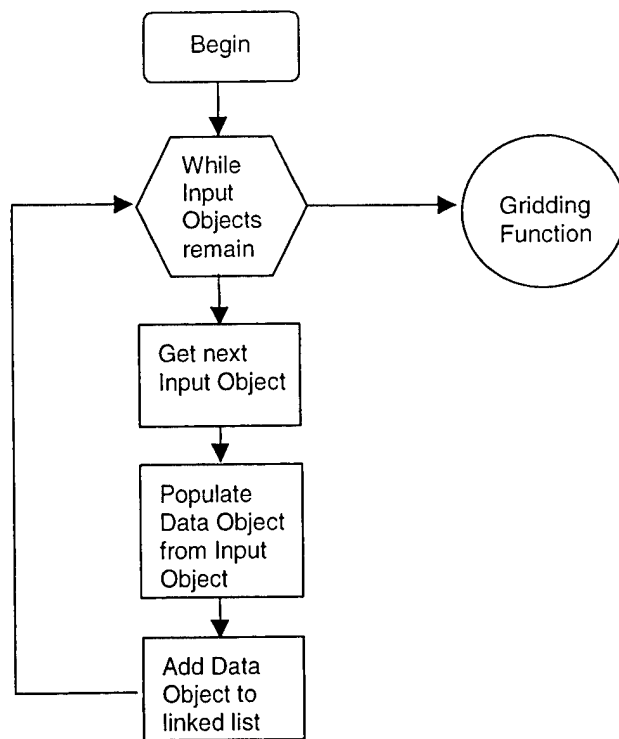
Figure 3-1: Object Interface Module Mapping

Figure 3-2: Data Input Process Flow Chart

3.2 Configure Mode

The ViBE Configure component is the user interface that allows the operator to adjust the energy weighting of the input objects to ViBE based on mission needs, domain knowledge, etc. It is also the component where the operator selects the Area of Interest (AOI) to be displayed. Figure 3-3 shows the Configure Process Flow Chart.
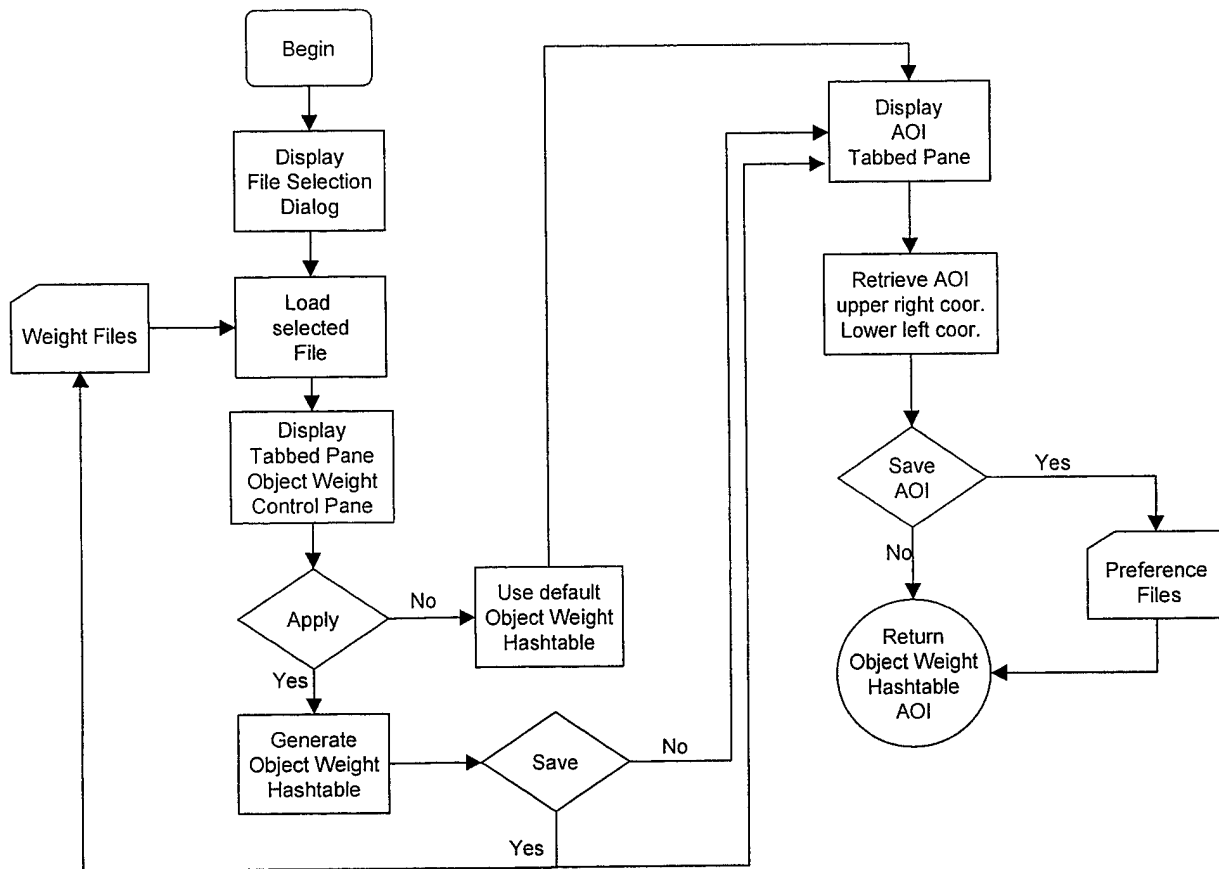
Figure 3-3: Configure Process Flow Chart

The Entity Mapping Hashtable discussed in Section 3.1.2 maps Object Groups to Energy Categories. (For example, an object type Tank 1 might map to an energy category Combat Vehicles.) The Configure Process loads a default object weight from a file. The Configure Process then parses this file and generates a tabbed pane Configure Panel. There is one tabbed pane generated for each category of energy listed in the file. Each tabbed pane is labeled with its energy category. Every group in the Entity Mapping Hashtable maps to an energy category on a tabbed pane. The Configure Process generates and displays on the tabbed pane a slider control to display and adjust the group weight. An energy category weight multiplier is added to the top of each tabbed pane so the operator can adjust the weight of an entire energy category.

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The operator has the flexibility to adjust the default weights of each object in each category by moving the corresponding slider. The operator can adjust the weight of an entire energy category by adjusting the weight multiplier at the top of that category's tabbed pane. The Configure Panel contains several option pushbuttons including:

Apply When chosen, the Configure Process builds an Object Weight Hashtable which is used by the energy algorithm to assign weights to the ViBE Data Objects during Energy Calculation Process.

Save Allows the user to save the current setting to an Object Weight File for retrieval at a later time.

Open Allows the user to retrieve energy settings stored in an Object Weight File saved from a previous operation of the Configure Process.

The Configure Process provides a tabbed pane that allows the user to define an AOI for which the battlespace energy will be displayed. The user can enter the coordinates in degrees, minutes and seconds of the upper left and lower right corners of the bounding rectangle. This AOI is passed to the Display and Gridding Processes.

3.3 Control Mode

The Control Process supports a GUI that allows a user to establish the Grid Cell Size, the Update Interval, the Frame Interval, the Frame Count, and the Color Selection Tool for the ViBE Display. The Control Process also supports a GUI that allows the user to filter the ViBE energy category and the ViBE groups.

Grid Cell Size The Grid Cell Size is a user-defined parameter used by the Gridding Function to determine how the ViBE Data Objects are grouped so that energy may be displayed on the map background. The Grid Cell Size can be selected in degrees, kilometers, or nautical miles.

Update Interval The Update Interval is a user-defined parameter that defines the time period during which the Energy Calculation Process sums up the energies of ViBE groups observed in the AOI. At the end of each Update Interval, the Energy Calculation Process passes a new grid cell list to the ViBE Display.

Frame Count The Frame Count is a user-defined parameter that defines the number of previous grid cell lists to be looped through on the map display in order to give the user a dynamic representation of battlespace energy.

Frame Interval The Frame Interval is a user-defined parameter that defines the time period during which previous grid cell lists will be shown on the map display.

Loop Interval The Loop Interval is a function of the Frame Interval, a simple multiplier to provide a pause between successive loops.

Color Selection Tool The Color Selection Tool allows the user to select colors that map specific energy intensities. ViBE has a default color mapping selected at

startup. The operator can use the Color Selection Tool to alter the default color mapping, or can retrieve a saved color mapping from a preference file. The operator can also save a color mapping to a preference file for subsequent retrieval. The color mapping is used by the ViBE Display in its depiction of battlespace energy.

Category Filtering   The ViBE GUI contains a tabbed pane of selection buttons that display all the ViBE energy categories. The operator can select one or all of the categories of energy to be displayed. The default setting is for all categories of energy to be displayed. Once a selection has been made, ViBE sets the weight multiplier of all unselected ViBE energy categories to zero.

3.4   Energy Calculation

The Energy Calculation process includes the Energy Algorithm and the Gridding Function. The Energy Calculation process takes as input ViBE Data Objects from the Message Dispatcher and passes, in a timed fashion, completed grid cell lists to the ViBE Display.

3.4.1   Energy Algorithm

The Energy Algorithm receives ViBE Data Objects from the Message Dispatcher. A ViBE Data Object is a structure that contains time received, ViBE group designation, and location (latitude and longitude). The Energy Algorithm takes each ViBE Data Object received and retrieves the group designation of that data object. Using the group designation as an index, the Energy Algorithm retrieves a ViBE weight and energy category from the Object Weight Hashtable computed in the Configure Process. The Energy Algorithm then constructs a new weighted ViBE Data Object containing time received, ViBE weight, energy category, and location (latitude and longitude). The weighted ViBE Data Object is then passed to the Gridding Function.

3.4.2   Gridding Function

The Gridding Function receives the weighted ViBE Data Objects from the Energy Algorithm and for a particular time interval t_1 and adds these ViBE Data Objects to a linked list of Grid Cell Objects. At the end of time interval t_1, the Gridding Function passes this linked list of Grid Cell Objects on to the Display Function. This process is depicted in Figure 3-4.

The process begins by initializing the current time to t_0. The Update Interval and the Grid Cell Size have been set by the Control Process, the Area of Interest of the scenario has been preselected by the configure process. A linked list of Grid Cell Objects is constructed containing each Grid Cell Object in the Area of Interest. The number of Grid Cell Objects is determined by dividing size of the Area of Interest by the Grid Cell Size.

Grid Cell Objects are structures identified by their latitude and longitude in the specified AOI. Each Grid Cell Object contains its location coordinates, a listing of each category of energy, the sum of the values of each category of energy in the specific cell, and a total sum of all the energies existing in that particular cell.
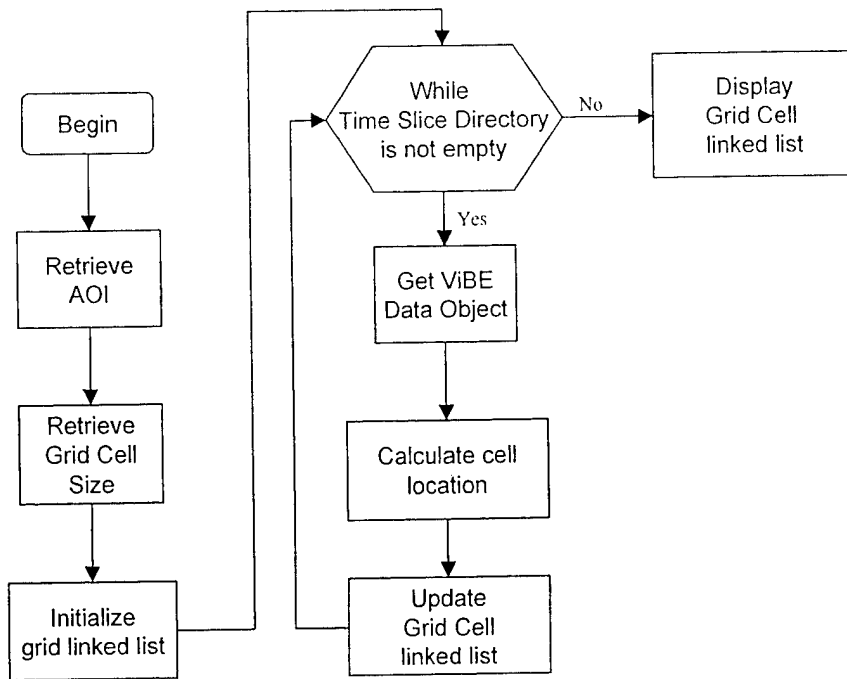
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Figure 3-4: Gridding Function Flow Chart

Each weighted ViBE Data Object passed to the Gridding Function is checked to see which grid cell the object occupies. The energy value obtained from the weighted ViBE Data Object is then added to the corresponding energy category in the Grid Cell Object. The total energy value of the Grid Cell Object is also updated.

When the Update Interval is reached, the Gridding Function removes all Grid Cell Objects from the linked list, which have a Total Weight equal to zero. The updated Grid Cell Object linked list is passed to the Display Function. A new Grid Cell Object linked list is initialized and the process continues until there is no more data being fed into the system.

3.5 Display

3.5.1 Realtime Display

The Display Function, highlighted in Figure 3-5, provides the user with a dynamic visual representation of the battlespace energy. It receives as input the Grid Cell Object linked list from the Gridding Function. The Display function also has color mapping parameters, time slice parameters, and category filtering parameters set by the user from the Control Function.

The Display Function loops through the linked list of grid cells. For each grid cell the Display Function retrieves the categories selected for display. The display function then maps the user-selected color to the Grid Cell Object based on weight and user-defined filter parameters. The display function then adds this object to the map overlay. At the end of looping through the linked list, the overlay will be displayed on the map background.
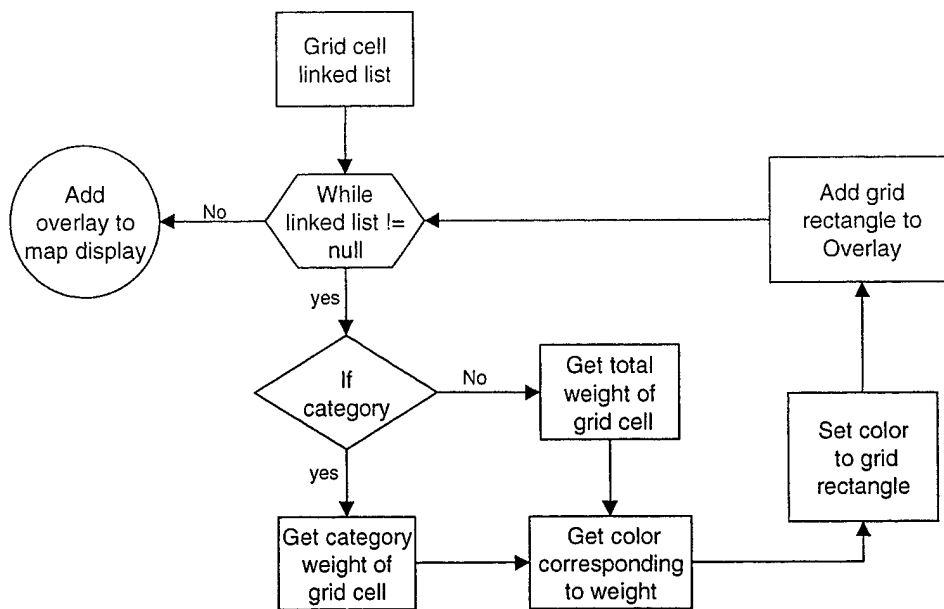
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Figure 3-5: Display Function Flow Chart

The user has an opportunity in the Control Panel to set the number of frames to be included in the display loop (Frame Count) and the length of time that a specific frame is displayed (Frame Interval). The Display Function has an array of grid lists that stores the number of grid linked lists specified by the user in the Control Panel. For example, the user has picked an Update Interval of one hour, a Frame Interval of two seconds, and a Frame Count of four frames. After the first hour of ViBE running, the first Grid Cell Object linked list is passed to the Display Function. The list is processed and then stored in the first Frame Array position. For the next hour there is no display loop because there is only one array element. After the second hour, the second grid cell link list is processed and stored in the second Frame Array position. The Map Display will then loop through these two array elements at two second intervals. At the end of four hours there is built up a loop of four grid cell lists, corresponding to four displays, as shown in Figure 3-6. After the fifth hour the array of grid lists is updated by removing the first hour grid list, shifting the remaining grid lists up one position and adding the fifth hour to the end of the grid list array.
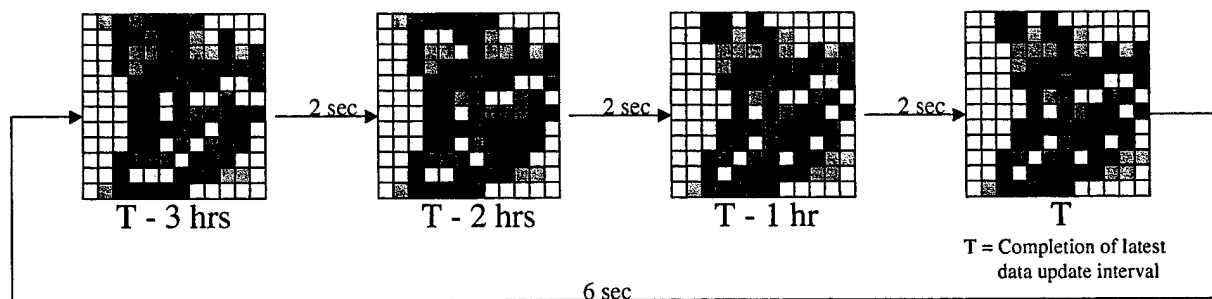

Figure 3-6: Display with Frame Count = 4, Update Interval = 1 hour, Frame Interval = 2 seconds

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The Map Display cycles through the Frame Array on a continuous basis giving the user a dynamic representation of the battlespace energy.

3.5.2 Playback Display

ViBE provides the user with the capability to re-view archived data.

The Playback and Realtime Display (previous section) processes are very similar. The main difference is that the playback process allows the user to select the start time of the playback loop and to reset the display options. For example, let us assume the current time is 2300 hours. The user wants to see the disposition of battlespace energy starting at 0800 hours. The user also selected a 30 minute Update Interval, a one (1) second Frame Interval, and a Frame Count of five (5). Playback would loop through the following five frames shown in Figure 3-7 at a one second interval.
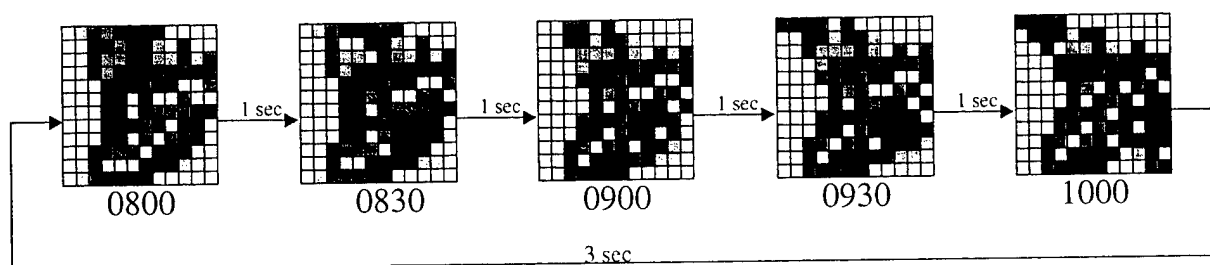

Figure 3-7: Playback with Frame Count = 5, Update Interval = 30 minutes, Frame Interval = 1 second

All of the ViBE configuration and control parameters except Area of Interest are modifiable during playback. This allows the user to filter out different object groups or to weight groups differently during playback.

3.6 Graphical User Interface

This section describes the elements of the graphical user interface (GUI) for ViBE. Each of the ViBE GUI Components is discussed in the following subsections.

3.6.1 ViBE Control Toolbar

The ViBE Control Toolbar shown in Figure 3-8 provides the following functionality. The first four buttons: *Control, Configure, Filter* and *Display* allow the user to select which of the four application panels (Control Panel, Configure Panel, Filter Panel, or Display Panel) that ViBE will have active in the Main Display Area. The Display Panel is the default panel. The functionality of each panel is outlined in Sections 3.6.6 through 3.6.9.

The *Set Map* button discussed in Section 3.6.1.1 allows the user to set and modify the display of background map data and its overlays. The map data and overlays are displayed in the *Display* Panel (Section 3.6.9).

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The *Realtime* (Section 3.6.1.2) and *Playback* (Section 3.6.1.3) buttons allow the user to run the ViBE system in either realtime or playback mode. These buttons are enabled once a Map has been set in the Main Display Area.

The *Pause* (Section 3.6.1.4) and *Restart* (Section 3.6.1.5) buttons are enabled once the ViBE system has started processing data.

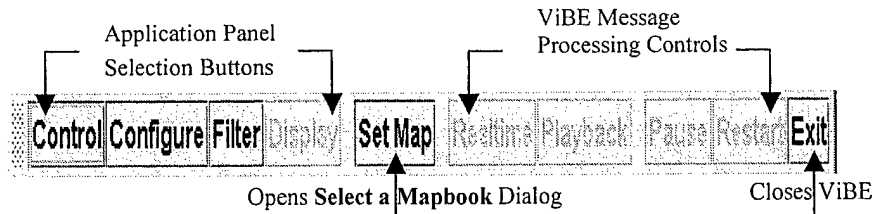The *Exit* button closes the entire ViBE application.

Figure 3-8: ViBE Control Toolbar

The ViBE Control Toolbar, and all other ViBE toolbars, are designed so that they may be "torn-off" and moved about the screen. To "tear-off" a toolbar, left click on the textured area to the left of the toolbar and drag it to the desired location.

3.6.2 Map Manipulation Toolbar

Once a map book is loaded, the Map Manipulation Toolbar (shown in Figure 3-9) is enabled. The Map Manipulation toolbar allows the user to select an object of interest on the map with *Pointer* button, to zoom in or zoom out with *Magnify* button, to pan with *Directional* button, or to re-center the map with *Center* button. The *select, bring to the front,* and *send to the back* buttons are not enabled.
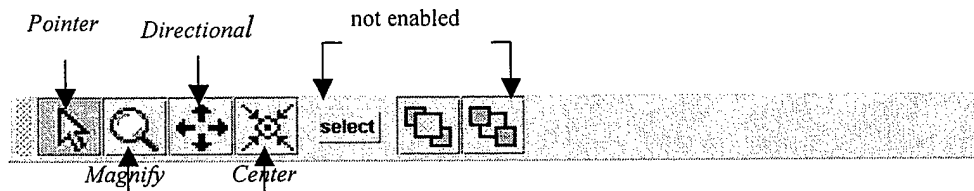

Figure 3-9: Map Manipulation Toolbar

3.6.2.1 Magnify Button Controls

To zoom in or out on the map display, click on the *Magnify* Button on the Map Manipulation Toolbar. This displays the magnification controls seen in Figure 3-10. (Figures 3-9, 3-10 and 3-12 are shown as a "torn-off" toolbars.) To increase the magnification of the map, click on the *Increase* magnification button. The *Size of Change* selection box indicates the number of times the magnification will increase (or decrease) when the *Increase* (or *Decrease*) button is clicked.

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The scale of the map display can be set specifically with the *Scale* selection box. To select a scale or size of change from the selection boxes click on the small arrow to the right of the current selection. This provides the scale settings that can be selected. Move the mouse pointer to select the new setting and click to apply.
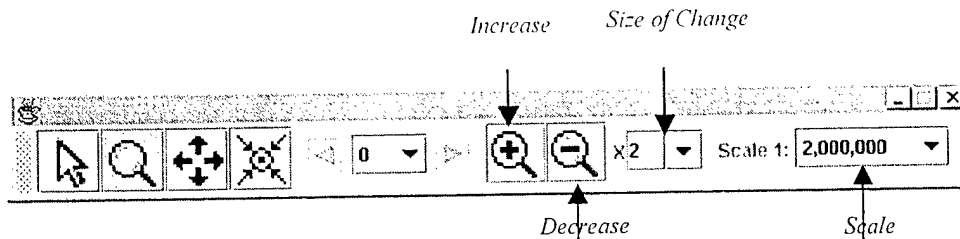

Figure 3-10: Map Manipulation Magnification

3.6.2.2 Directional Button Controls

Once the *Directional* button is clicked the Directional Control shown in Figure 3-11 is displayed. The value in the middle of the display is the percentage of map that will be moved when an arrow is left clicked. To increase or decrease this value, click on the grab bar and drag to a new value. To close the Directional Control, click on the *X* in the upper right corner.
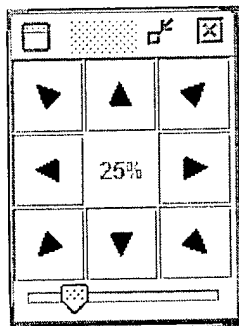

Figure 3-11: Directional Controls

3.6.2.3 Center Button Controls

When the *Center* button is clicked as a red point appears at the current center of the map display. To re-center the map, click on the *Center* button, then click on the map display. The map will be re-drawn with this point as a new center point. The coordinates of the new map center may also be entered into the text box provided (Figure 3-12). Coordinates are in the DDMMSSN DDDMMSSN format, for example, entering 353040N 1252530E will center the map at a latitude of 35 degrees 30 minutes 40 seconds North and a longitude of 125 degrees 25 minutes 30 seconds East. When the new center point coordinates are complete, click on the *Center* button to re-draw the map with this new center point.
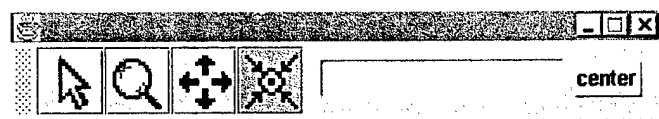
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Figure 3-12: Map Manipulation Center

3.6.3 Time Toolbar

The toolbar shown in Figure 3-13 displays the Current Scenario Time and the Current Frame Time, in days, hours and minutes Universal Time (Z) for the data being processed.
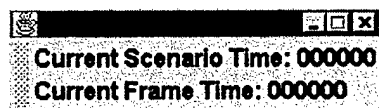

Figure 3-13: Time Toolbar

3.6.4 ViBE Color Legend

This toolbar shown in Figure 3-14 provides a key for the energy level of the cells shown on the Display Panel. The lower levels of battlefield energy are shown by the colors to the left of the toolbar and the higher by the colors to the right. These colors can be recalculated or changed in the Control Panel on the Misc. Tabbed Pane.
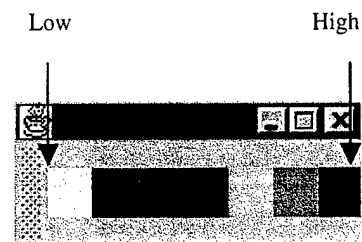

Figure 3-14: ViBE Color Legend

3.6.5 Playback Control Toolbar

The ViBE Playback Control toolbar, shown in Figure 3-15, starts the ViBE processor in Playback mode. This toolbar is visible only if the *Playback* button is selected from the ViBE Control Toolbar. To start the playback of ViBE data, left click on the *Play* button. At this time, this toolbar is not currently fully enabled. The *Play* button is the only functional button. To pause/resume or restart the processing, use the *Pause/Resume* button located on the ViBE Control Toolbar.
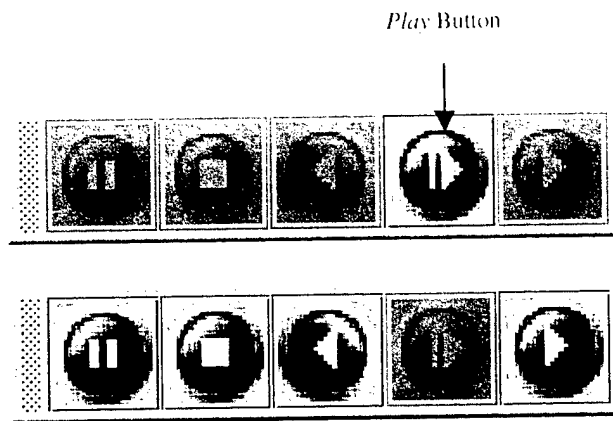
Figure 3-15: ViBE Playback Control Toolbar

3.6.6 Configure GUI

Figure 3-16 shows a screen displayed when the user clicks the *Configure* button, one of the Mode Selection buttons located in the upper left corner of the ViBE Control Toolbar. Pressing the *Configure* button displays a series of tabbed panes in the Display Window. Clicking on a tab brings that particular pane forward and activates the controls on that pane. For instance, the pane displayed in Figure 3-16 is the Ground Combat Tabbed Pane. This tabbed pane identifies the type of energy to be weighted. The horizontal slider at the top of the pane has a label corresponding to the category. This allows the user to set a multiplying factor to be applied to the entire category. There are multiple vertical sliders on each tabbed pane. Each slider corresponds to one group belonging to the energy category. The user sets the energy weighting of each group by adjusting its slider. Pressing the *Apply* button on the ViBE Settings and File Controls accepts the settings.
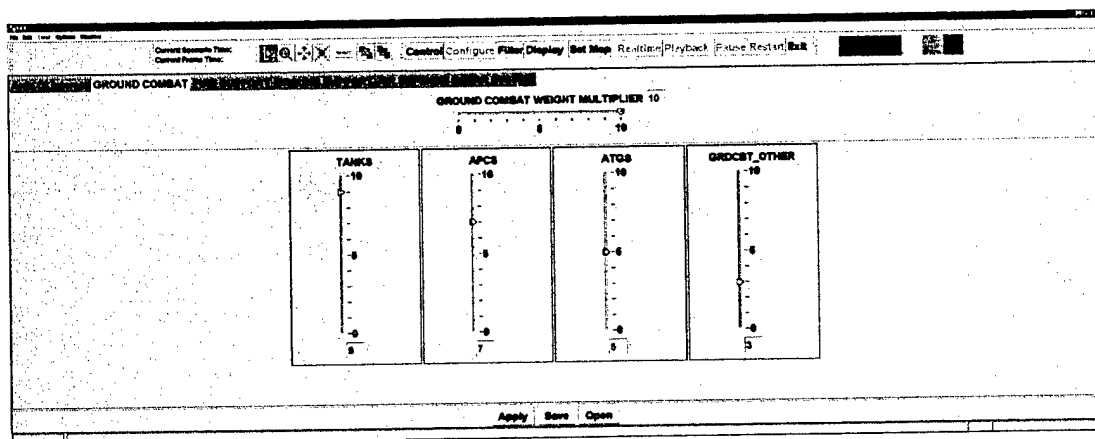

Figure 3-16: Configure Panel with Ground Combat Tabbed Pane Displayed

3.6.7 Control GUI

Figure 3-17 shows the ViBE Control Panel. The Control Panel also implemented as a series of tabbed panes. The operator clicks on the tab of the control feature to be adjusted bringing that pane to the front. The operator then makes the necessary adjustments and clicks the *Apply* button at the bottom of the screen committing the changes.
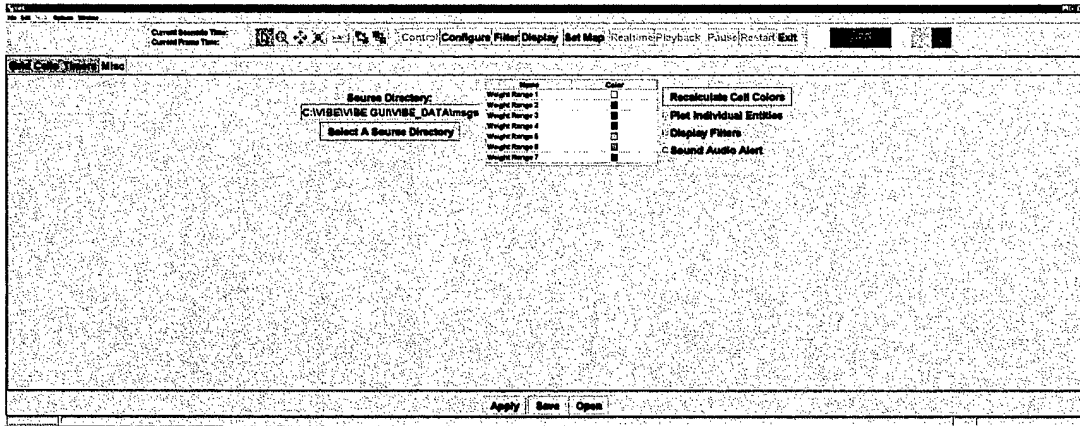

Figure 3-17: Control Panel with Misc. Tabbed Pane Displayed

3.6.8 Filter Panel

The Filter Panel, shown in Figure 3-18 allows entire categories or groups of entities to be removed from the energy display. This provides the flexibility, for example, to remove the energy display for the entire ground combat category or the Tank group. To select the Filter Panel, click on the *Filter* button on the ViBE control toolbar. Select a specific tab by left clicking on the name of the tab shown along the top of the main display area.

Selecting the Categories Tabbed Pane allows the user to remove the energy display for an entire category, while selecting the Groups Tabbed Pane allows the user to remove the energy display for the individual groups of entities.
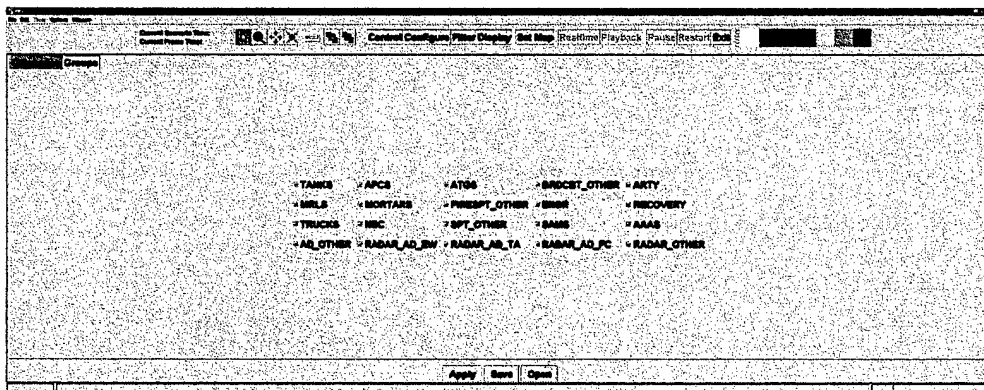

Figure 3-18: Filter Panel with Groups Tabbed Pane Displayed

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3.6.9 Display Panel

Figure 3-19 shows the ViBE Display GUI with the energy grid overlay. This is the main display of both the Realtime and the Playback modes of the ViBE system. The different colors depict different levels of energy in the current battlespace.
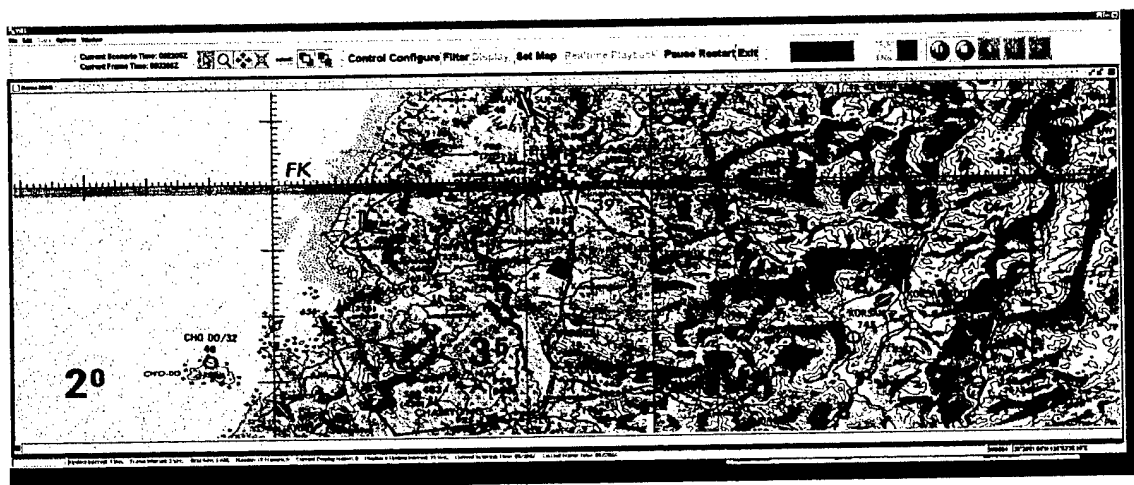

Figure 3-19: ViBE Display Panel

SECTION 4 CONCLUSIONS AND RECOMMENDATIONS

This section presents conclusions from the ViBE effort and offers recommendations for future work improvements to the ViBE system.

4.1 Conclusions

The ViBE software system was designed to be an integrated DataWall visualization capability processing all-source intelligence data. The system consolidates that intelligence data geospatially as energy corresponding to the potential combat power of a military force and displays that energy on a map using innovative visualization techniques.

The system enhances Commander-level situational awareness by bridging the gap between the commander's or planners' needs and the detailed operational views created by today's fusion systems. ViBE helps identify high-level trends (movement, build-ups, major routes, etc.) and cyclic patterns (day/night, day of week, seasonal) along with providing support for Center of Gravity (COG) analysis. The system can support course of action analysis, campaign/operational planning and execution, as well as target selection/prioritization. If incorporated into a traditional fusion system, ViBE can provide a starting point for "drilling down" into more detailed operational views, or as a tool to help direct sensor concentration.

ViBE also accomplished the goal of demonstrating many of the capabilities of the DataWall. It sizes the map to the dimensions of the DataWall and was built to facilitate use of the mobile mouse-pointer.

4.2 Recommendations

4.2.1 Operational Concept Assessment

ViBE was developed with the intent of demonstrating an innovative method for visualizing battlespace dynamics. Up to this point, demonstrations of ViBE have been limited to the research community. To more fully assess the operational feasibility and value of this visualization technique, a more comprehensive assessment approach should be developed, soliciting feedback from a broad range of potential users.

4.2.2 Demonstration Scenarios and Data

Because of its potential to process and rapidly display representations of activity based on data from many sources, large data sets that realistically represent future information sources should be used. The resources available for this project depended on existing data sources, exclusively from simulators. These sources do not include some existing and envisioned data sources that have the potential to significantly contribute to the demonstration of ViBE's visualization capabilities. Moving Target Indicator (MTI) data is an example. When more of these data sources evolve and are simulated in exercises or realistically participate in exercise scenarios, ViBE should be reviewed and updated to integrate them.

4.2.3 Movement Pattern Analysis and Alerts

Because of the dynamic high-level depiction of enemy activity through ViBE, this application offers potential for analyzing patterns of activity in the dimensions of time and space. An automatic detection capability could be integrated that would alert the viewer when a pattern of movement met some pre-defined criteria. For example, if there was a detection of energy weights that exceed a specified threshold in a set of cells, ViBE could flash an alert. This could be based on intelligence indicators and warnings (I&W). In many scenarios, we know that if there is a significant increase in the volume of traffic along certain lines of communication, that is an indicator of logistical positioning to support an attack. If ViBE with such a capability had been technologically possible in December 1944, Eisenhower would have been forewarned of the German attack into what history now knows as the "Bulge."

Note the red-boxed area in Figure 4.1. This could represent an avenue of approach expected to be used by an enemy force. The area enclosed by the red line could be designated by ViBE as an I&W alert area. By calculating the average energy weight in the cells within that area and comparing that to a user-designated threshold, ViBE could provide an alert on the screen.
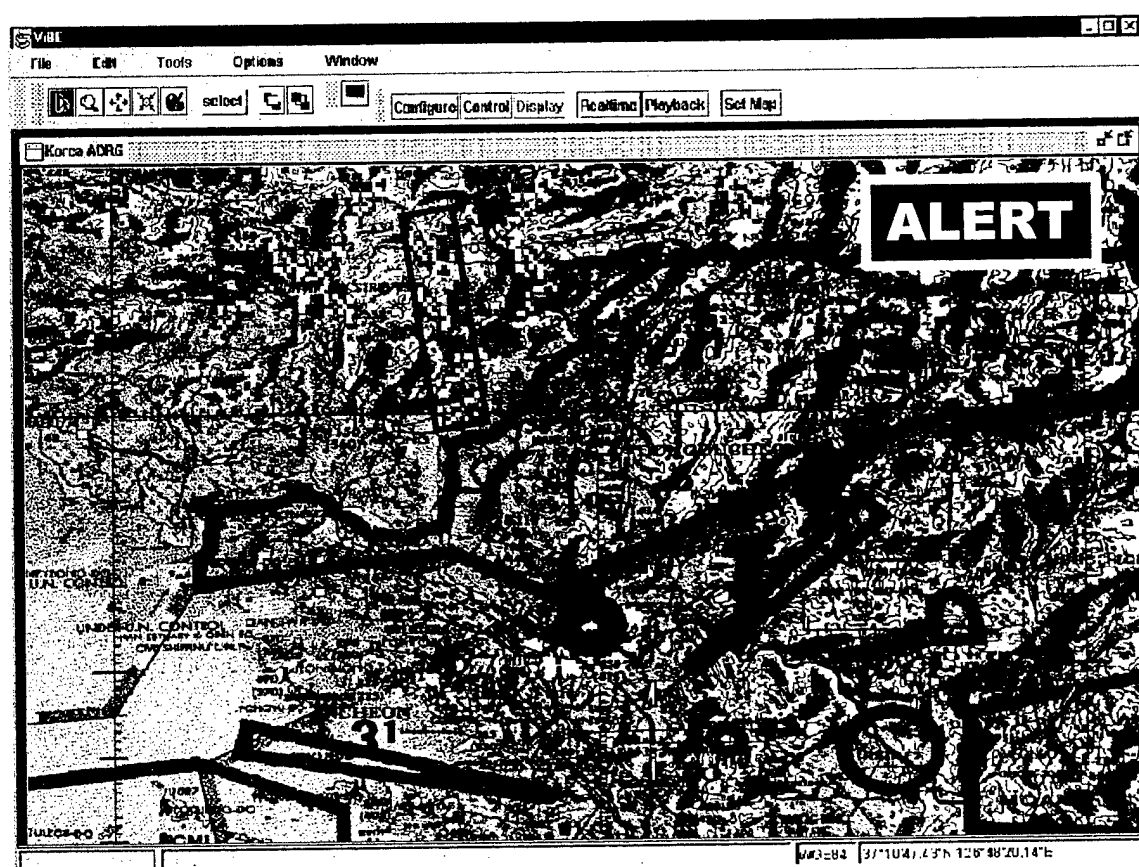

Figure 4-1: Conceptualization of Indicators and Warnings Analysis and Alerts through ViBE

4.2.4 C4ISR System Integration

From the start of this effort, we did not envision ViBE providing detailed situational awareness for a battle staff. It provides a <u>high-level</u> visualization of enemy activity. However, it can be useful as a basis for determining where activity may warrant more detailed information. ViBE could have links to other applications that provide the necessary detail. For example, links could be established so that if the ViBE user defines an area on the map (based on increased indicators of enemy activity) by drawing a box or other interface method, a menu list appears with collection assets targeting that area or fusion engines currently processing data for that area. ViBE could even be the platform for launching other C4ISR based applications. There is also potential to hook ViBE in with the Adaptive Sensor Fusion (ASF) architecture currently under development by AFRL/IFEA.

4.2.5 Distributed Capabilities

During this project, we experimented with a distributed capability. We built and demonstrated the capability to remotely view the ViBE display from a remote system. However, this required less than trivial work to adapt the underlying mapping software (MapVision) for this purpose. Because of limitations with MapVision, we were not able to implement a web-base approach as hoped. That is still a worthy goal and adaptation of the software to support this would be worthwhile.

4.2.6 Visualization Concept Extension

The technical approach used for ViBE is applicable to applications other than "battlespace energy." The weighted grid cell methodology is adaptable to other uses. Any need for rapid visual understanding about the presence and density of entities or activity based on geolocation could be represented by ViBE. Examples might be pollution levels, radiological measurements, and population densities.

APPENDIX A ACRONYMS

This section lists and defines the various acronyms used in this report.

AFRL	Air Force Research Laboratory
AOI	Area of Interest
ASE	Advanced Sensor Exploitation
ASF	Adaptive Sensor Fusion
AWACS	Airborne Warning and Control System
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
COG	Center of Gravity
COTS	Commercial Off-The-Shelf
FTR	Final Technical Report
GIP	Generic Intelligence Processor
GUI	Graphical User Interface
IMINT	Imagery Intelligence
I & W	Indicators and Warnings
LCD	Liquid Crystal Display
MTI	Moving Target Indicator
SIGINT	Signal Intelligence
TREC	Target Recognition for Electronic Combat
USAF	United States Air Force
USMTF	United States Message Text Format
ViBE	Visualization of Battlespace Energy

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